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STEALTH PLUMES ON IO - T. V. Johnson, D. L. Matson, D. L. Blaney, G. J. Veeder (Calbxh/Jet l'repulsion Laboratory, Pasadena, CA, 91 109), and A. Davis (NRC Associate, Caltech/JPL)

Some of the most spectacular expressions of Io's volcanic activity arc the large, umbrella shaped eruptive plumes discovered in Voyager camera images (Morabito *et* al., Science, 204, 972, 1979; Smith *et al.*, *Ibid.*, 951-972, 1979). These plumes rise to altitudes of several hundred kilometers, implying ballistic vent velocities of 0.5- 1.0 km/s (Strom and Schneider, in Satellites of Jupiter, D. Morrison, cd., U. of Ariz. Press, 1982). At least nine such plumes were observed in eruption by Voyage.r, eight of them apparently active over the four months separating the Voyager encounters, and there is abundant evidence in the images for surface deposits from similar activity at many other locations.

The primary model proposed to explain these features involves phase change, geyser-like eruptions in Io's relatively low gravity and negligible atmosphere. The theoretical basis for this class of eruptive activity has been laid by S. Kieffer, who has explored a wide variety of possible composition, reservoir and vent combinations which could produce the observed characteristics of the plumes (S. Kieffer, in Satellites of Jupiter, 1982). The most likely driving fluids for Jo plumes arc believed to be SO_2 (which has been detected as both solid and gas on Io) and sul fur (proposed as both a coloration agent on the surface and as a possible candidate for tava flows).

Most previous discussions of plume models have concentrated on Prometheus type plumes driven by SO_2 in contact with liquid sulfur at -400 K. These "low to moderate entropy" eruptions can supply the necessary energy to drive a plume to the observed heights ($\geq \sim 100$ km) and arc consistent with the range of temperatures observed in 10 hotspots by the Voyager infrared spectrometer (l'car] and Sinton, in Satellites of Jupiter, 1982). in this regime the geyser emerges from the vent as a low temperature (- 100 K) mixture of gaseous and solid SO_2 moving at high velocity (-0.5 -0.6 km/s) (see Kieffer's fig. 18.5, Reservoir Ill). The resultant plume is readily observable through light scattered from the SO_2 condensates.

We propose that another class of plume may be even more common on 10 than those detected by Voyager - "high entropy" SO_2 eruptions energized by contact with silicate magma. Infrared observations of Io over the last decade have detected short lived hotspots with temperatures indicative of silicate lava ($\geq -$ 1000 K) and analyses of these events and the characteristics of the thermal anomalies on Jo suggest that silicate volcanism may be responsible for most of the hotspot and resurfacing activity (Johnson *et al.*, Science, 242, 1280-1283, 1988; Veeder *et* al., J. Geophys. Res., 99, 17,095-17,162, 1994; Blaney *et* (Il., Icarus, in press, 1 995). Under these conditions, and given the ubiquitous nature of SO_2 deposits observed on the surface and inferred in the subsurface from the detected plumes, it is likely that the conditions required for Kieffer's "high entropy" eruptions from Reservoir V may be common. This reservoir is characterized as "SO_1 superheated vapor in contact with or degassing from a hypothetical silicate melt at 1.5 km depth...".

Sulfur dioxide eruptions under these conditions have a number of interesting characteristics. They can easily supply the same high vent velocities seen for the lower entropy cases, but the eruption proceeds entirely in the vapor phase, with a flow of high velocity, cold gas emerging from the vent into the near-vacuum above 10's surface. Such plumes would not have been detected by Voyager's instruments. The gas in the plumes is far too tenuous for the camera to detect by molecular scattering, and the IRIS detected SO_2 in absorption only where a large column of cold gas was in front of a large hot source on the surface. (Loki was the only location where this occurred). Thus, such a plume would, in effect, be a "stealth plume".

At this point it is not possible to estimate precisely how many high entropy plumes might be erupting at a given time. "There are large uncertainties in the total amount of SO_2 being cycled through the atmosphere and surface and in the creation of the required reservoir conditions. However, it is entirely possible that these purely gaseous eruptions are more common than the visible plumes seen by Voyager. Recent observations of SO_2 gas on Io using microwave spectroscopy (Lellouch *et al.*, Icarus, 98, 271-295, 1992) suggest that SO_2 is distributed in a "patchy" manner covering 5-20% of the surface, as opposed to a uniform atmospheric layer. Lellouch *et al.* (1994) suggest that the observed microwave spectral characteristics might be produced by cold gas in many ballistic plumes. However, the total area covered by plumes detected by Voyager is less than that suggested by the microwave results. We suggest that unseen "stealth" plumes may be responsible for the additional SO_2 apparently detected by Lellouch *et al.*

It has also been noted that 10's ionosphere inferred from the exit profile of Pioneer 10's radio occultation was essentially above the most prominent and long lived volcanic feature on Io - Loki Patera (Johnson and Matson, in Origin and Evolution of Planetary and Satellite Atmospheres, [1. of Ariz. Press, 1989). The entry profile however is not associated with any known Voyager plume. If there are in fact more gas plumes than suggested by the Voyager observations, it seems likely that any spacecraft occultation has a good chance of sampling a "locally" derived atmosphere. Thus Galileo, with several planned radio occultations, has an opportunity to determine better the distribution of gas and plum activity on Io.

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